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GRUMMAN **N.E.** TRACKING RANGE
SHOT PUT III DATA

Final Report

12P

FINAL REPORT
SHOTPUT III DATA
GRUMMAN NORTHEAST TRACKING RANGE

PGR-C-11

MAY 1960

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FINAL REPORT ON SHOTPUT #3

CONTRACT #NAS 1-584

INTRODUCTION

In accordance with the terms of Contract #NAS 1-584 the Grumman Aircraft Engineering Corporation has analyzed and prepared final reports on the National Aeronautics and Space Administration's experiments designated Shotput 2 and Shotput 3. The final report on Shotput 2 was submitted by Grumman letter #874-460, dated 13 April 1960.

SCOPE

The Shotput 3 report consists of reduced time, event and position data derived from photographs taken by cameras of the Northeast Tracking Range during the experiment designated Shotput 3, which was launched by the National Aeronautics and Space Administration from Wallops Island, Virginia on 27 February 1960.

The following major areas of interest were analyzed:

- a. Trajectory of the 100-foot sphere.
- b. Sequence of events measured against absolute time.
- c. Dispersion of second-stage smoke trail.

EQUIPMENT

The basic camera system of the Northeast Tracking Range is the modified Fairchild K19B aerial camera with an Aero Ektar F2.5 lens of 305 mm focal length. Kodak Royal Pan film was used in the cameras adapted for cut film and Tri-X was used in magazine-fed units. All shutters were driven by a secondary crystal-controlled time standard which was synchronized with the time signal transmitted by the U. S. Naval Observatory. Each shutter was pulsed open for a quarter of a second out of every second. Shutter actuation, hence, individual exposures, may be described in absolute time with an accuracy approaching \pm one millisecond. The time during which each camera operated is shown in enclosure (1).

Each photograph was exposed for an average of thirty seconds, giving a total effective film exposure of 7.5 seconds.

ANALYTICAL PROCEDURE

The balloon earth track (enclosure 2), vertical trajectory (enclosure 3) and performance profile (enclosure 4) are calculated from our photographic plates using an analytical procedure which is carried out on the IBM 704. This procedure is believed to be at least as accurate as the photographic data, so that given perfect plates and timing, it should place the balloon within hundreds of feet or seconds of arc.

A spheroidal earth is assumed, using international values, and the body of the calculation is performed using geocentric coordinates. The result, however, being quoted in geodetic. Refraction effects are minimized by using a star background where both stars and balloon are equally affected. Selection of stars whose axis passes close to the balloon further minimizes the effects of both refraction and unequal film stretch.

A series of coordinate transformations transforms the cartesian coordinates of the balloon on the plate into apparent celestial coordinates from the station, and then into the terrestrial coordinates of the apparent subpoint. A series of vector multiplications, using results from corresponding plates, yields the balloon's vector, which is then translated into geodetic coordinates, height and tapeline distance.

FUNCTIONING OF PAYLOAD

The sphere began to inflate at 18 hours 23 minutes 50 seconds Eastern Standard Time and took two seconds to reach apparent maximum volume for the flight. Halation around the central image was first photographed one second after initial sighting of the balloon, indicating that the high volume leakage commenced at that time.

No particles, such as occurred during Shotput One, were observed during this experiment. As far as can be determined, the balloon remained intact.

Scintillation or rapid change in apparent magnitude was not observed during the visible trajectory. It may be concluded that the balloon maintained a near-spherical shape.

The balloon was lost in earth shadow at 18 hours 30 minutes 45 seconds E.S.T.

WIND SHEAR

The smoke trail left by the second-stage rocket was analyzed to determine the effects of wind shear; hence, some measure of wind velocity. The analysis was made from photographs taken during the interval between 18 hours 23 minutes 19 seconds and 18 hours 29 minutes 19 seconds, using triangulation from three stations to determine relative position and direction of the shear planes. Enclosures (5) through (7) graphically represent the velocity, displacement, direction, and altitude of the smoke trail dispersion.

DISCUSSION OF COMPUTED RESULTS

This report is based chiefly on data points computed by means of Grumman's new I.B.M. 704 reduction program. As a check on the new program, all computations were worked concurrently by hand, employing seven significant figures for angle functions.

It is felt that the success of the new computer program will enable the Northeast Tracking Range to furnish both preliminary and final data reports at a very reasonable interval after future experiments.

Several data point inconsistencies, especially noticeable in the earth track plot, are most likely attributable to defective interpretation of absolute time recordings at the #6 camera.

The preliminary radar data points supplied by N.A.S.A. were plotted on enclosures (2), (3), and (4) for comparison. No attempt has been made to analyze the apparent lack of conformity to the photographic data.

SUMMARY

The second-stage rocket carrying the Shotput 3 experiment aloft was first photographed at 18 hours 22 minutes 31 seconds Eastern Standard Time at an altitude of 37.1 nautical miles above Wallops Island. Burnout occurred at 18 hours 23 minutes 05 seconds E.S.T.

The 100-foot sphere was first observed at 18 hours 23 minutes 50 seconds and took two seconds to reach apparent maximum volume. Halation around the balloon began one second after first sighting, indicating that high volume leakage commenced at that time.

No particles were sighted near the balloon. Scintillation was not observed.

The balloon was lost in earth shadow at 18 hours 30 minutes 45 seconds E.S.T.

SHOTPUT # 3

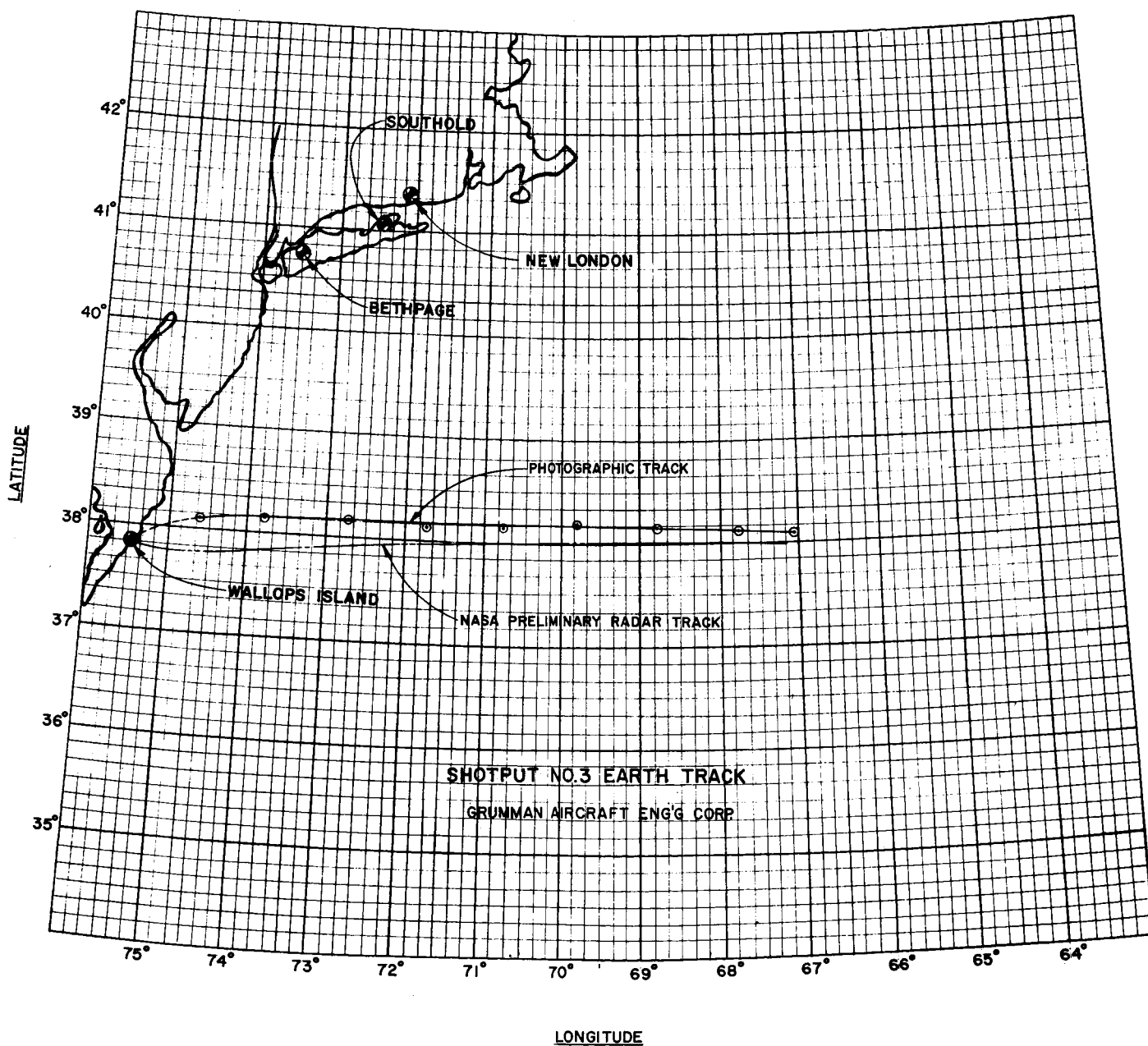
February 27, 1960

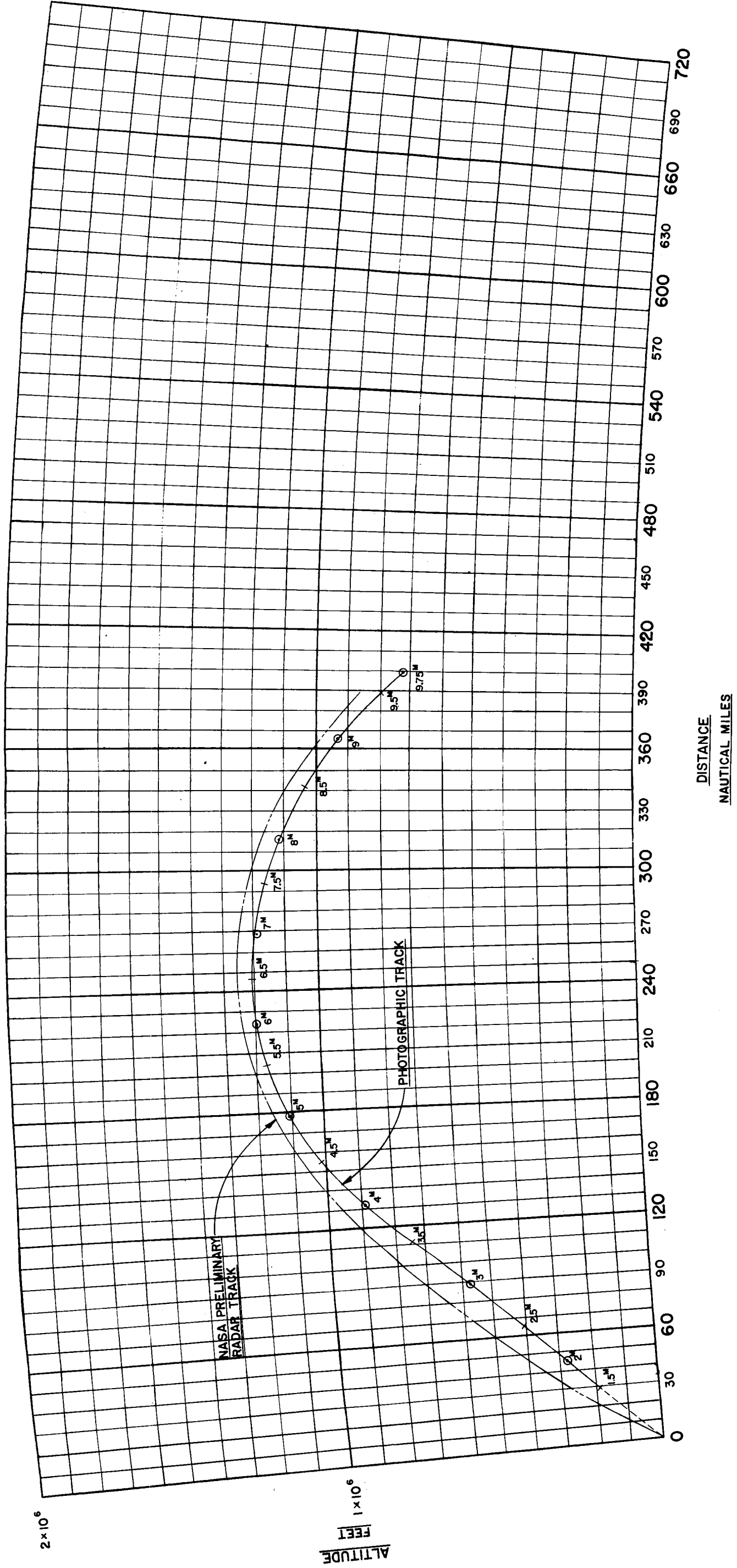
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	<u>Bethpage</u>	<u>Bethpage</u>	<u>Bethpage</u>	<u>Bethpage</u>	<u>Southold</u>	<u>New London</u>
1	21:31-22:04	22:01-22:34	21:16-21:49	21:47-22:19	21:00-21:31	21:30-22:01
2	22:31-23:04	23:01-23:34	22:18-22:49	22:47-23:19	22:00-22:31	22:30-23:01
3	23:31-24:04	24:01-24:33	23:16-23:49	23:47-24:19	23:00-23:31	23:30-24:01
4	24:31-25:04	25:01-25:34	24:16-24:49	24:47-25:19	24:00-24:31	24:30-25:02
5	25:31-26:04	26:02-26:34	25:16-25:49	25:46-26:19	25:00-25:31	25:30-26:01
6	26:31-27:04	27:11-27:34	26:16-26:49	26:46-27:19	26:00-26:31	26:30-27:01
7	27:31-28:04	28:01-28:34	27:16-27:49	27:47-28:19	27:00-27:31	27:45-28:04
8	28:31-29:04	29:19-29:34	28:16-28:49	28:47-29:19	28:00-28:31	28:30-29:01
9	29:31-30:04	30:01-30:34	29:18-29:49	29:47-30:22	29:00-29:31	29:30-30:01
10	30:31-31:06	No Exposure	30:19-30:49	30:46-31:15	30:17-30:47	30:30-31:01

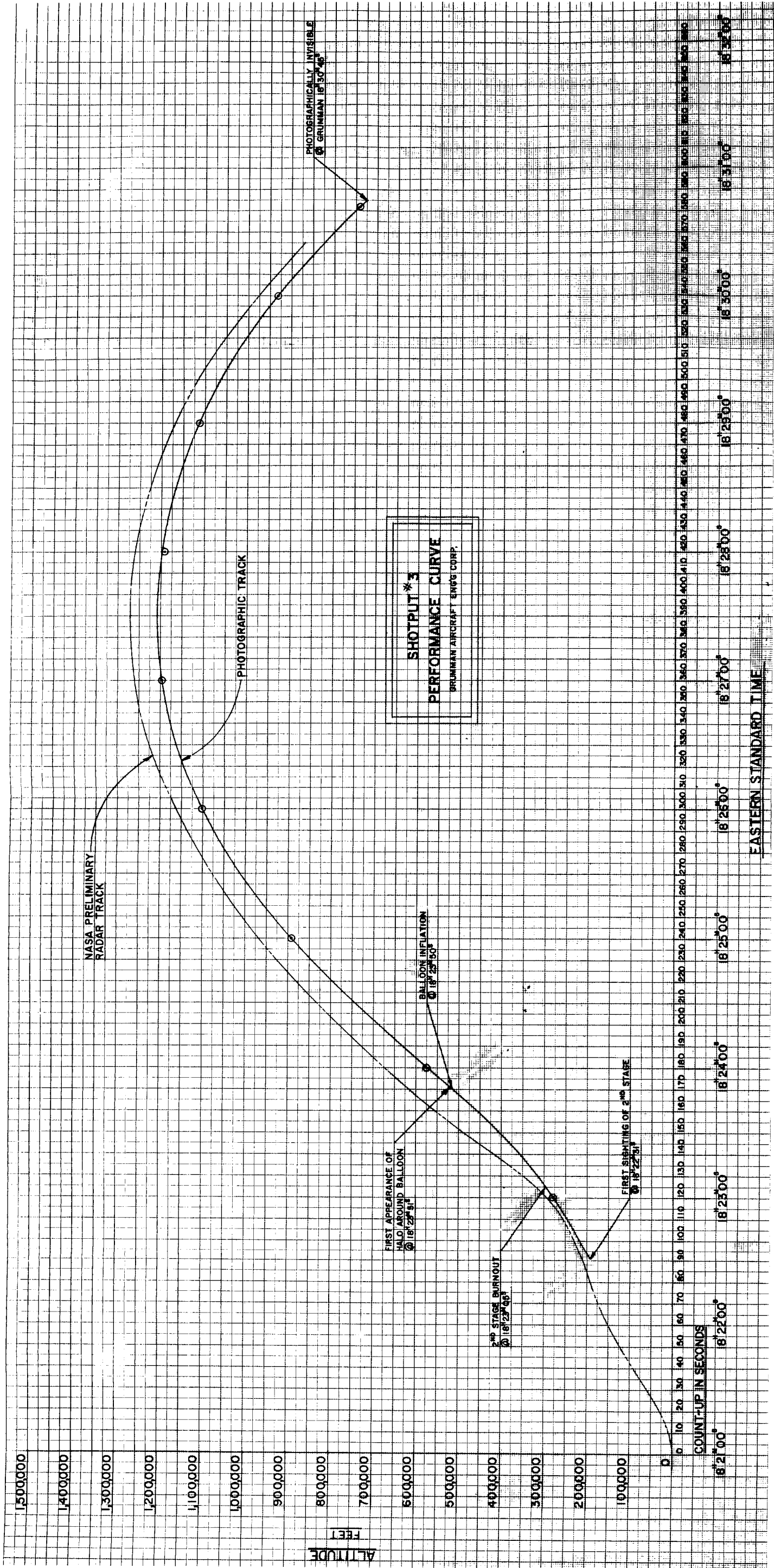
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NOTE: TIMES ARE IN MINUTES AND SECONDS AFTER 1800 HOURS.





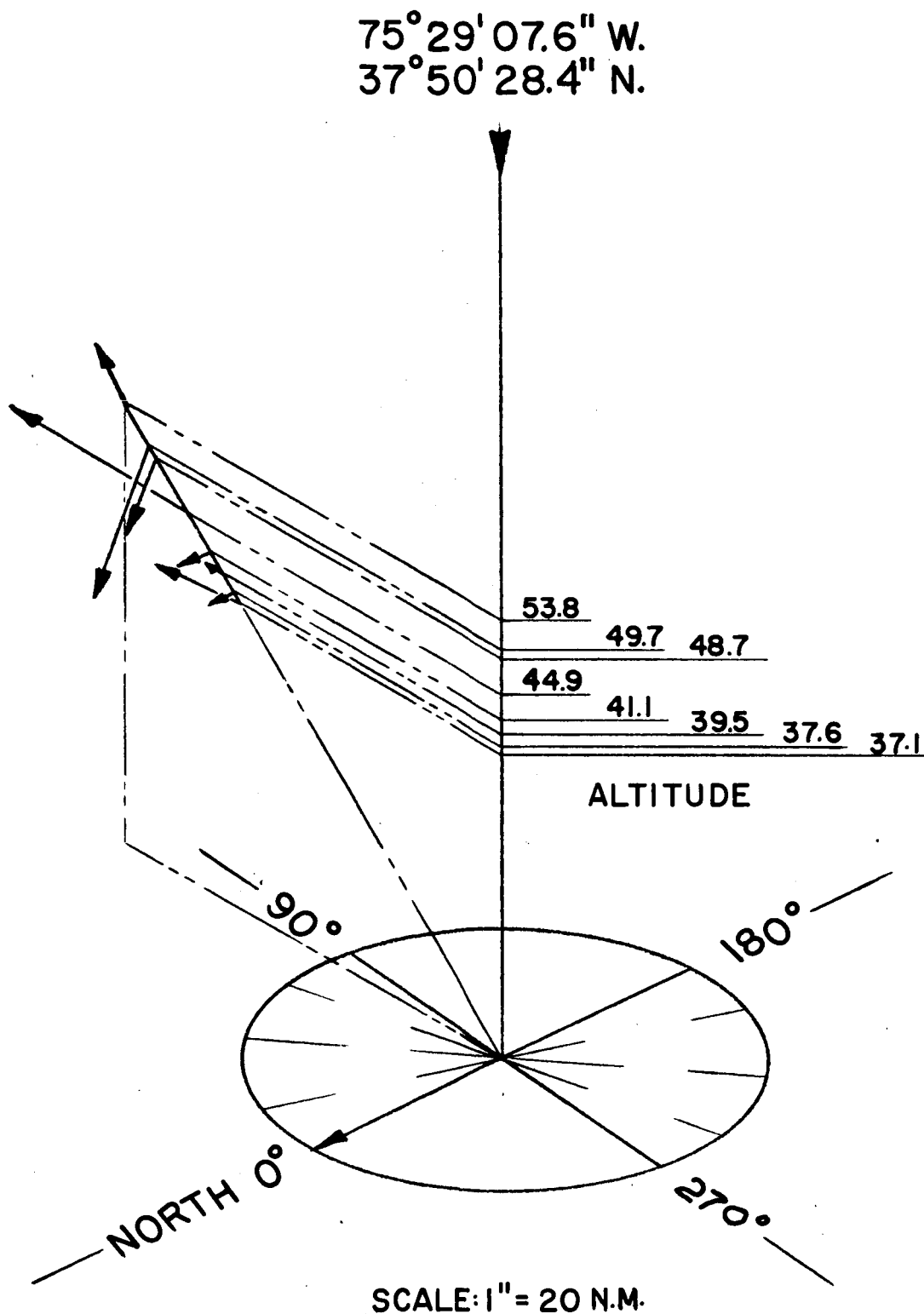
TRAJECTORY IN SPACE FOR SHOTPUT # 3
GRUMMAN AIRCRAFT ENG'G CORP.



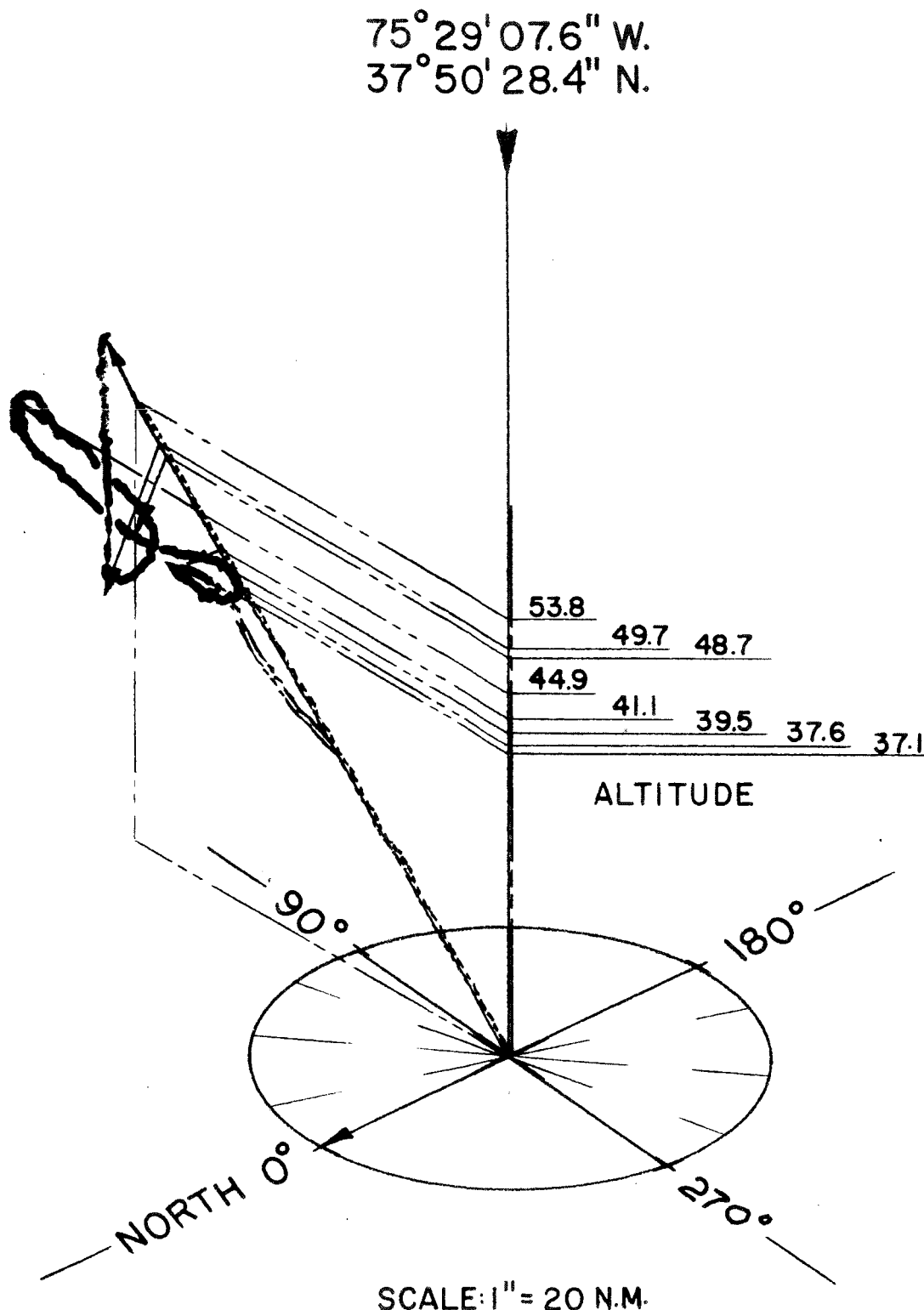


SMOKE TRAIL OVERLAY

SHOT PUT 2



SCALED VIEW SMOKE TRAIL
SHOTPUT 3



SMOKE TRAIL OVERLAY
SCALED VIEW SMOKE TRAIL
SHOTPUT 3

ALTITUDE IN NAUTICAL MILES

0 10 20 30 40 50 60 70 80

20 40 60 80 100 120 140 160 180 200 220 240 260 280

VELOCITY IN KNOTS

WIND SHEAR GRAPH

SHOTPUT 3 - FEB. 27, 60

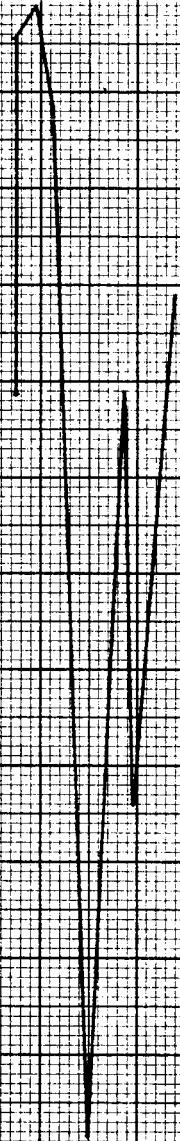


TABLE
WIND SHEAR VALUES
SHOTPUT 3

ALTITUDE NAUTICAL MILES	ALTITUDE IN FEET	SHEAR DIRECTION	DISPLACE- MENT IN NAU. MILES	VELOCITY IN KNOTS	TIME
37.1	225,568	76°	11.4	113.6	TOTAL ELAPSED TIME 6 MINUTES TO OBTAIN VALUES FOR D.8.V.
37.6	228,608	360°	2.9	28.5	
39.5	240,160	90°	2.2	22.4	
41.1	249,888	2°	4.3	42.5	
44.9	272,992	88°	25.7	256.9	
48.7	296,096	329°	10.3	102.6	
49.7	302,176	327°	18.8	188.1	
53.8	327,104	115°	8.3	82.3	